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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MONTHLY DISTRIBUTION OF SHIPPING VESSELS WITHIN THE MONTEREY BAY NATIONAL MARINE SANCTUARY, JANUARY-DECEMBER 2010

by

Christopher W. Miller

September 2011

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Prepared for: Monterey Bay National Marine Sanctuary
Monterey, CA 93940

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After the discovery of a forty foot shipping container resting on the ocean floor within the Monterey Bay National Marine Sanctuary (MBNMS), the MBNMS began a study to research the impact that containers lost at sea might have on the marine environment. The Naval Postgraduate School Oceanography Department was approached to provide some measure of the total shipping which passes within the boundaries of the MBNMS. Utilizing the Automated Identification System (AIS) message data, both total shipping and cargo shipping totals were calculated and monthly density plots were generated to show those areas which are most impacted by vessel traffic. In addition to providing informing the issue of lost shipping containers, these plots can also be used by the MBNMS and NOAA's other West Coast Sanctuaries to understand interactions between shipping and wildlife, especially within the context of ship strikes to whales.

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ABSTRACT

After the discovery of a forty foot shipping container resting on the ocean floor within the Monterey Bay National Marine Sanctuary (MBNMS), the MBNMS began a study to research the impact that containers lost at sea might have on the marine environment. The Naval Postgraduate School Oceanography Department was approached to provide some measure of the total shipping which passes within the boundaries of the MBNMS. Utilizing the Automated Identification System (AIS) message data, both total shipping and cargo shipping totals were calculated and monthly density plots were generated to show those areas which are most impacted by vessel traffic. In addition to providing informing the issue of lost shipping containers, these plots can also be used by the MBNMS and NOAA's other West Coast Sanctuaries to understand interactions between shipping and wildlife, especially within the context of ship strikes to whales.

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I. INTRODUCTION

In June 2004, the Monterey Bay Aquarium Research Institute (MBARI) came across a 40' shipping container during a scientific dive with their Remotely Operated Vehicle in the Monterey Submarine Canyon. The container was traced back to the merchant vessel *Med Taipei,* which departed from San Francisco February 25, 2004, and subsequently lost 24 containers as it transited to Los Angeles during a winter storm. Following this discovery, and subsequent legal efforts, the Monterey Bay National Marine Sanctuary (MBNMS) and MBARI created a research program to follow the impacts of containers in the marine ecosystem, and further investigate the potential impacts of shipping within the National Marine Sanctuaries.

To investigate the quantity of shipping that transits the Sanctuary, the Naval Postgraduate School (NPS) Oceanography department was approached by MBNMS staff to request available data. To support this request, available Automated Identification System (AIS) message data, which continually broadcast vessel location and cruise information (identification, location, speed, vessel type, etc.), have been processed and analyzed over the bounds of the MBNMS. This information is also of interest to MBNMS and other West Coast Sanctuary staff seeking to better understand the interactions between shipping and wildlife, especially the phenomenon of ship strikes to whales.

II. AIS DATA

The Vessel Traffic Service (VTS), the marine equivalent of the more familiar air traffic control, in collaboration with the International Maritime Organization (IMO) established the AIS messaging system to increase the safety of navigation of vessels at sea. A required part of a vessels navigational electronics, the AIS transmitter/receiver is fully integrated with the global positioning system (GPS) and ship's systems to automatically report vessel identification, position, speed over ground, course over ground, ship type and dimensions. Additional static data messages are also transmitted with ship's name, vessel type, call sign, dimensions and destination.

The general built-in identifiers to report ship type are: Wing-in-Ground (WIG), high speed craft (HSC), Passenger ships, Cargo ships, tankers, and other. Each of these ship types can further be distinguished to designate if they are carrying dangerous goods, hazardous cargo or marine pollutants as defined by IMO categories A, B, C or D. Special craft class identifiers are provided for: pilot vessels, search and rescue vessels, tugs, port tenders, vessels with anti-pollution facilities or equipment, law enforcement vessels, and medical transports. Other ship identifiers are defined for: fishing, towing, dredging or underwater operations, diving operations, military operations, sailing and pleasure craft.

The AIS messages are broadcast using Very High Frequency (VHF) radio waves. Like any radio broadcast, the effective range of transmission varies significantly depending on weather conditions. Since the VTS system was designed for ship-to-ship, or ship-to-port communications, this shortcoming is not a concern for navigational safety, but does come into play when evaluating large scale ship movements. AIS receivers are concentrated around major port areas, and while additional receivers have been added over the years, there are still conditions and occasions where available coverage is not complete. Additional vessel identification errors are also evident in the decoded messages, with default Maritime Mobile Service Identity (MMSI) registry value being seen, as well as other cruise information data which requires manual updates by the bridge crew to be correct. These messages were disregarded when it could impact the analysis.

The International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) issued the first guidelines for AIS in 2002, with vessel compliance dates to 2004 (Table 1). As a maritime safety system, the ship-to-ship and ship-to-port coverage was the first implementation goal, with approximately 184 VHF receiver stations located throughout the coastal United States. Once major port coverage was in place (San Francisco, Los Angeles, and Long Beach along the California coast) the Coast Guard's next focus was inland waterways, leaving large gaps along the central California shipping lanes. In 2008, in an effort to augment the limited coverage provided by the port entry areas, the Naval Postgraduate School began installing networked AIS receivers along the central California coast at Port San Luis, Point Sur, Monterey, Pescadero Point, and Bodega Bay (Figure 1).

Table 1. AIS Carriage requirement compliance dates.

Vessel type	**Compliance date**
Self-propelled vessels of 65' or more in length, other than passenger and fishing vessels, in commercial service and on an international voyage	December 31, 2004
Passenger vessels, of 150 gross tonnage or more	July 1, 2003
Tankers, regardless of tonnage	July 1, 2003
Vessels, other than passenger vessels or tankers, of 300 gross tonnage or more but less than 50,000 gross tonnage	December 31, 2004
Self-propelled vessels of 65' or more in length, other than fishing vessels and passenger vehicles certified to carry less than 151 passengers-for-hire, in commercial service	December 31, 2004
Towing vessels of 26' or more in length and more than 600 horsepower, in commercial service	December 31, 2004
Passenger vessels certified to carry more than 150 passengers-fore-hire.	December 31, 2004

Figure 1. NPS AIS receiver stations (stars) along central California.

III. RESULTS

Available AIS message reports, grouped by reporting vessel, were used to identify those ships that passed through the MBNMS over the course of 2010.

A. POSITION REPORT LOCATIONS

Monthly position report plotting was performed to give an overall view of data coverage and a general sense of where vessel traffic occurs. These figures are provided to give a sense of data coverage only, as they lack any temporal reference. These figures are based solely on reported AIS position messages. While this provides the best available knowledge of shipping activity during this period, it cannot be considered complete (AIS coverage gaps, vessels disabling or transmitting incorrect information, etc.).

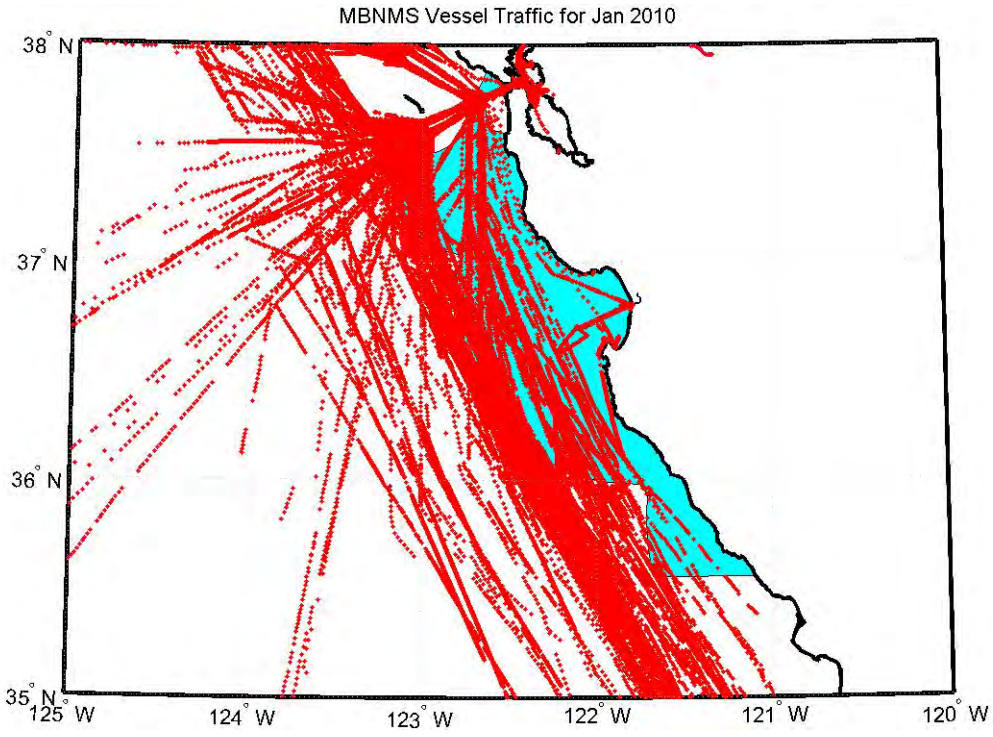

Figure 2. AIS position message reports for January 2010.

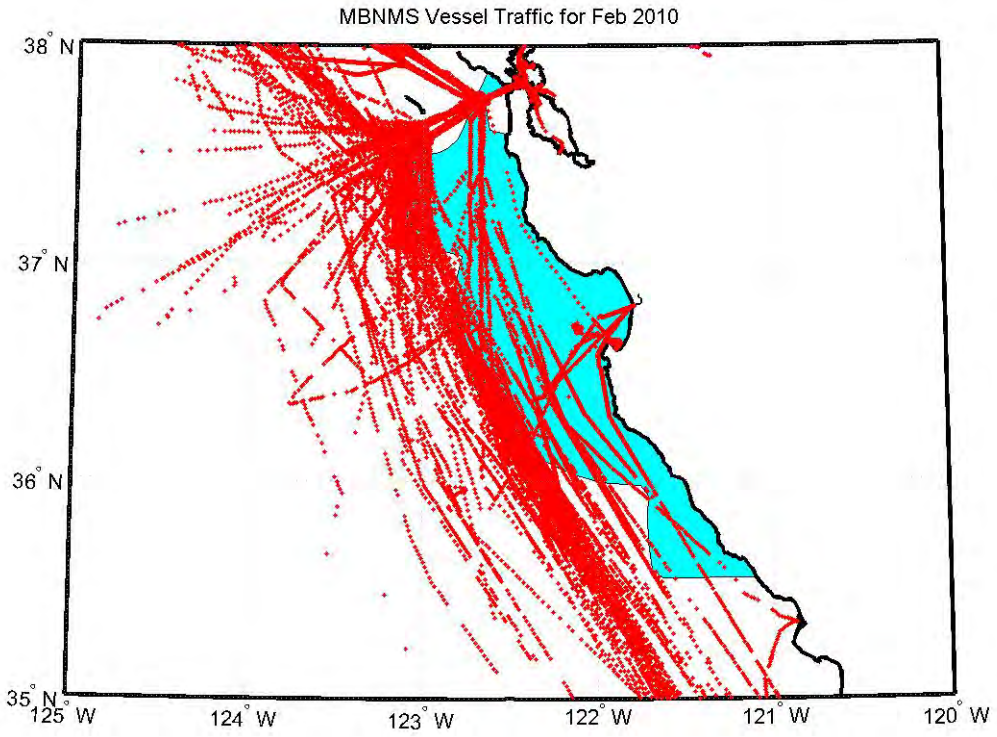

Figure 3. AIS position message reports for February 2010.

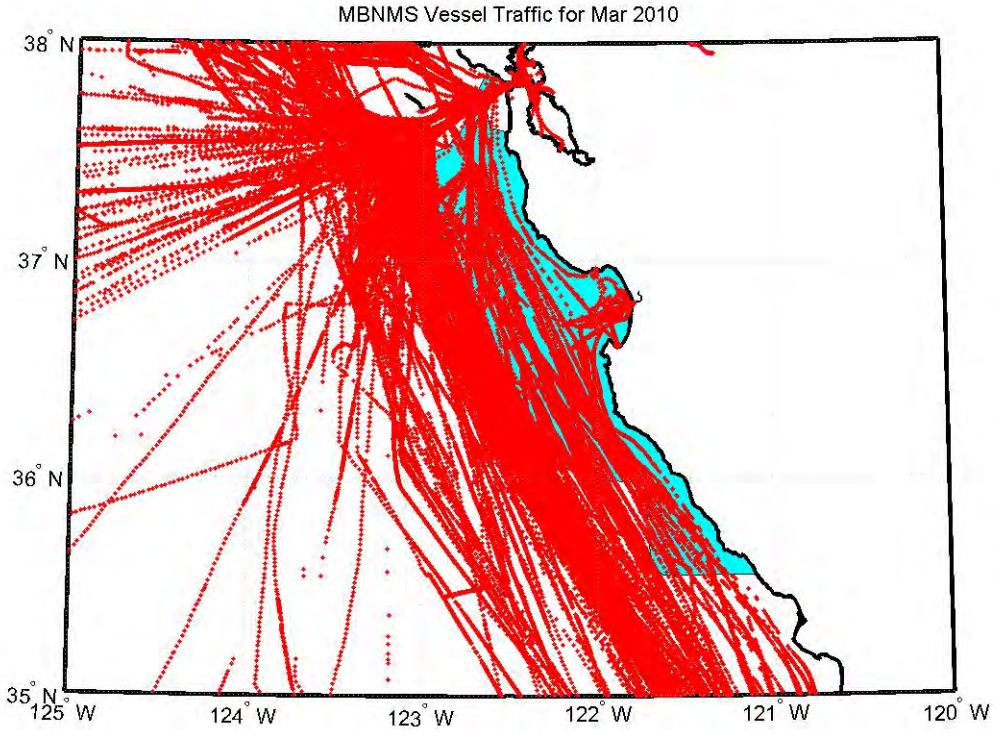

Figure 4. AIS position message reports for March 2010.

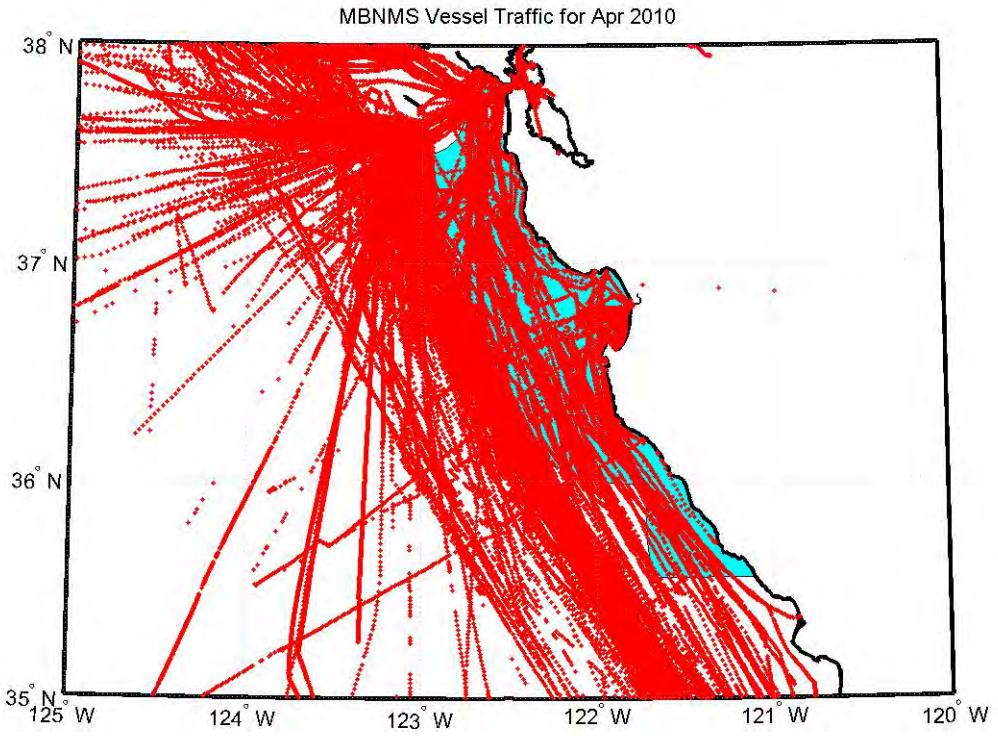

Figure 5. AIS position message reports for April 2010.

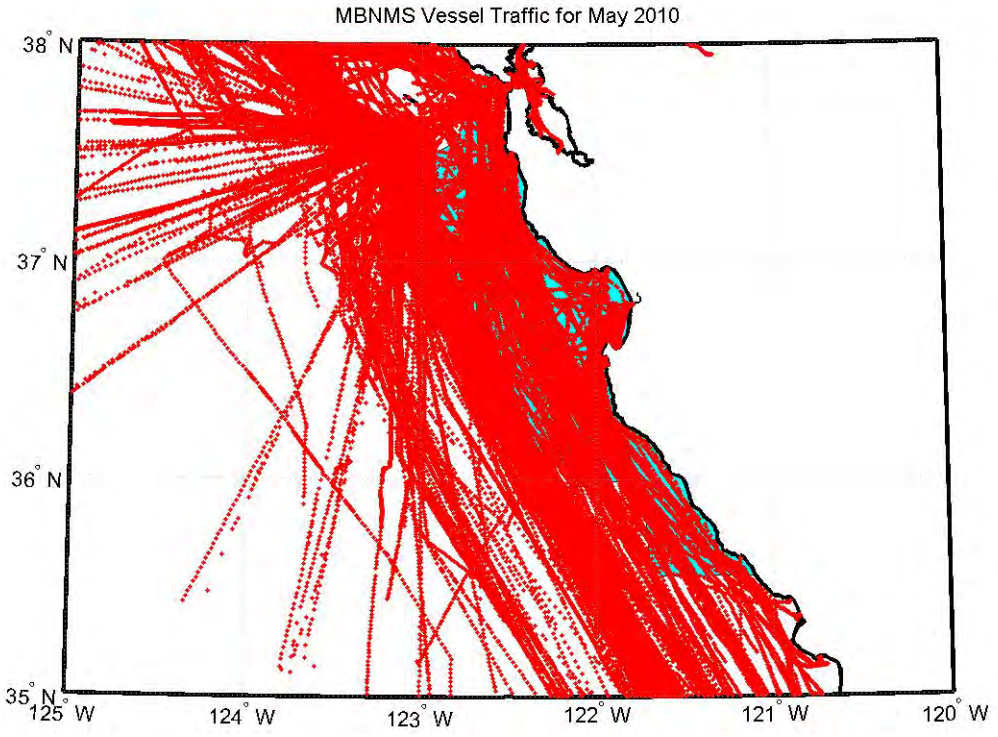

Figure 6. AIS position message reports for May 2010.

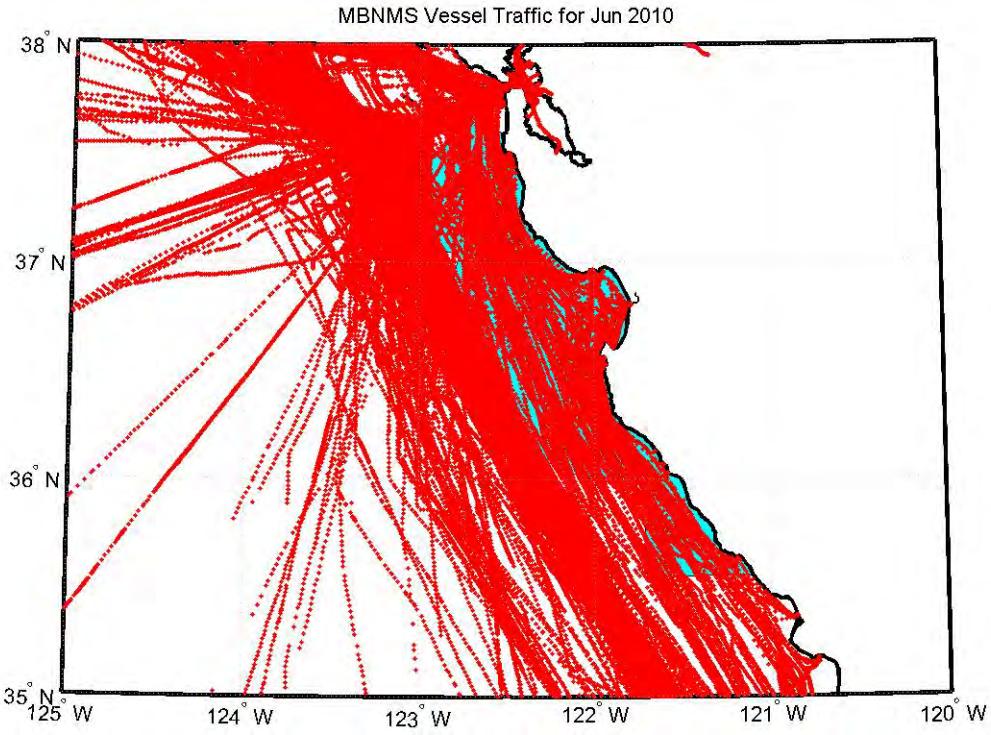

Figure 7. AIS position message reports for June 2010.

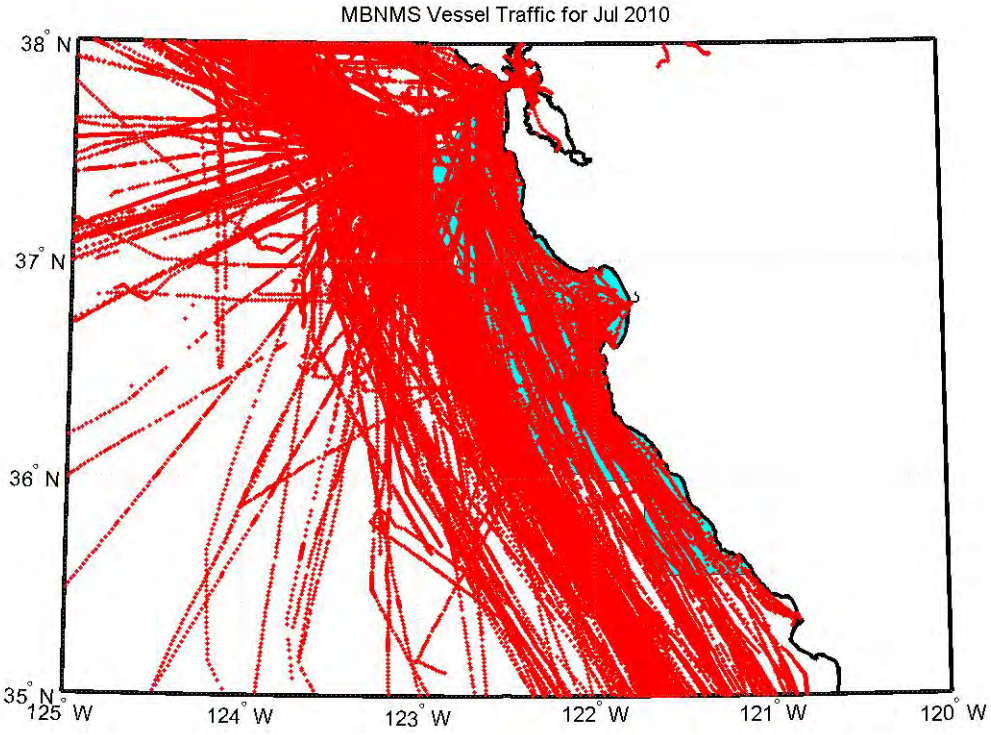

Figure 8. AIS position message reports for July 2010.

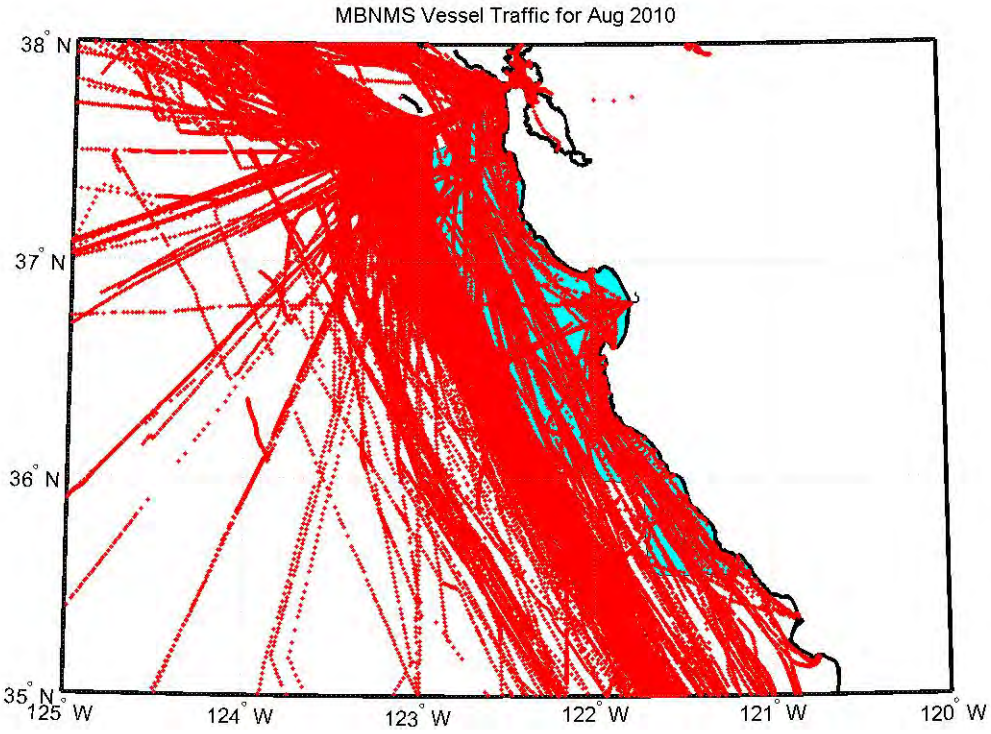

Figure 9. AIS position message reports for August 2010.

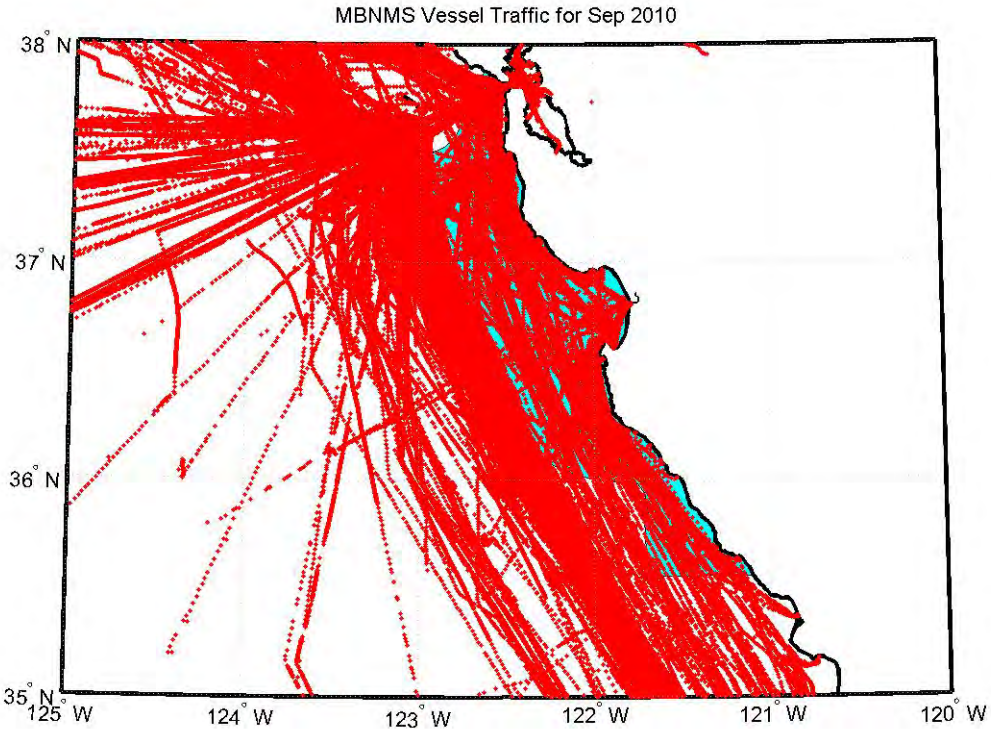

Figure 10. AIS position message reports for September 2010.

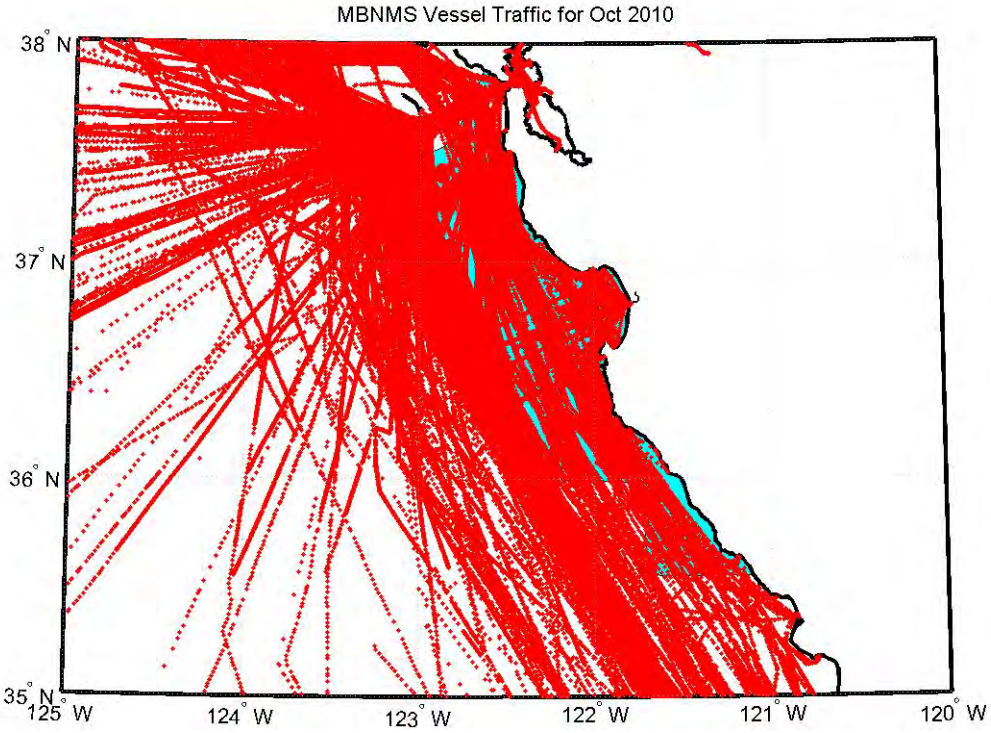

Figure 11. AIS position message reports for October 2010

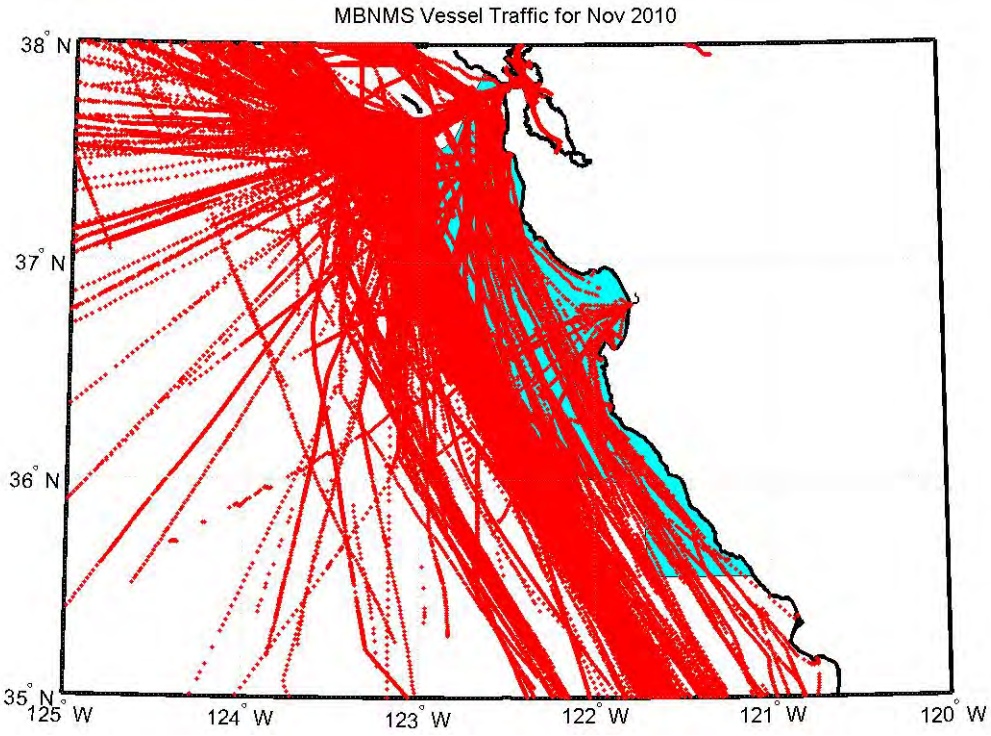

Figure 12. AIS position message reports for November 2010

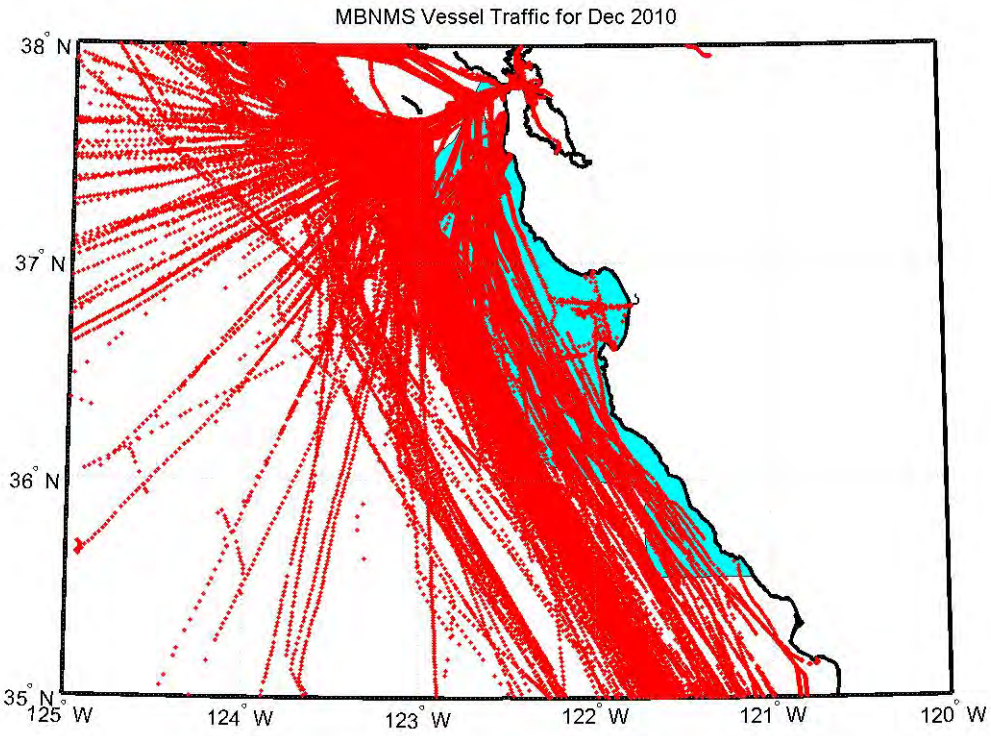

Figure 13. AIS position message reports for December 2010

B. MONTHLY SHIPPING DENSITIES

Daily position reports of each vessel was interpolated to a 1 square arc-minute resolution, on a 1-minute time scale. Monthly ship densities along the California coast were then generated based on the total number of "ship-minutes" all vessels occupied each 1 square arc-minute of space. In some cases large gaps in received AIS messages cause the interpolation to show results that pass over land in error; in others, multiple ships were broadcasting the default MMSI identification number in error. The color axis of the ship density plots, Figures 14-25, represent the total number of minutes vessels spent in one square arc-minute of area over the course of the month. The color range was truncated at 120 min. to ensure sufficient contrast to distinguish the traffic patterns at sea, rather than having the harbor vessels dwarf the available resolution of the seagoing traffic as a ship sitting pier-side over the course of a month would total 43,200 minutes.

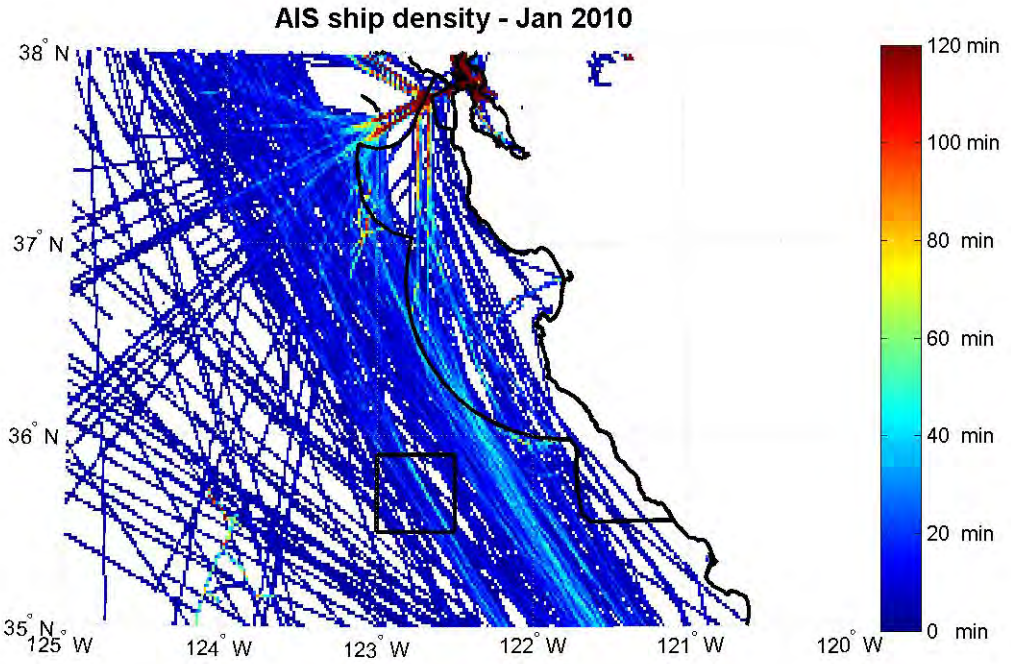

Figure 14. Monthly ship density for January 2010.

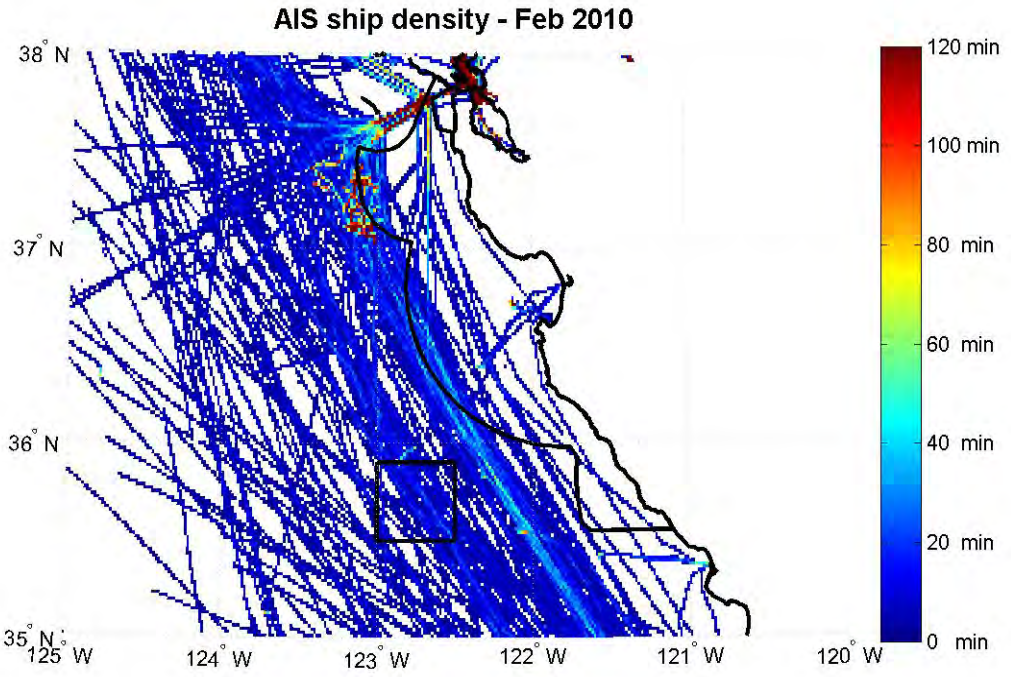

Figure 15. Monthly ship density for February 2010.

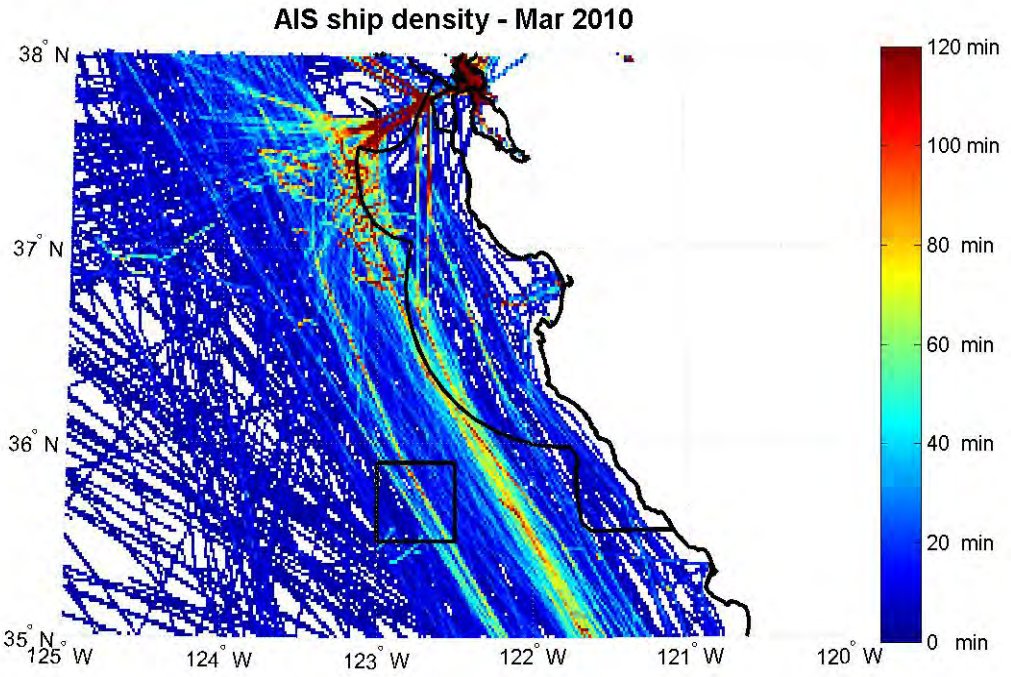

Figure 16. Monthly ship density for March 2010.

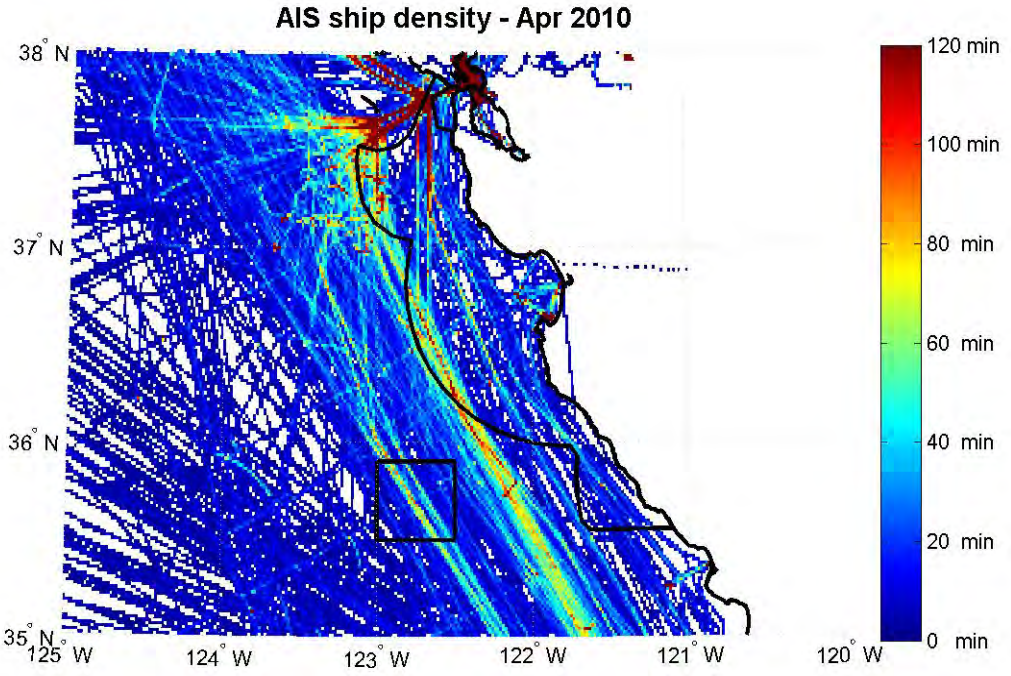

Figure 17. Monthly ship density for April 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

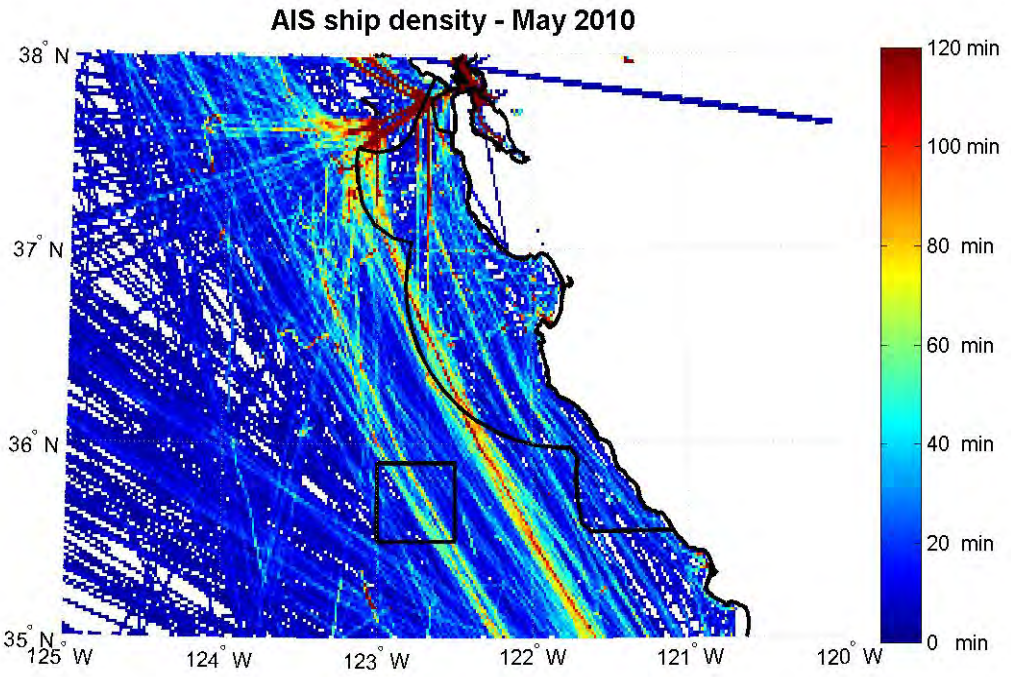

Figure 18. Monthly ship density for May 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

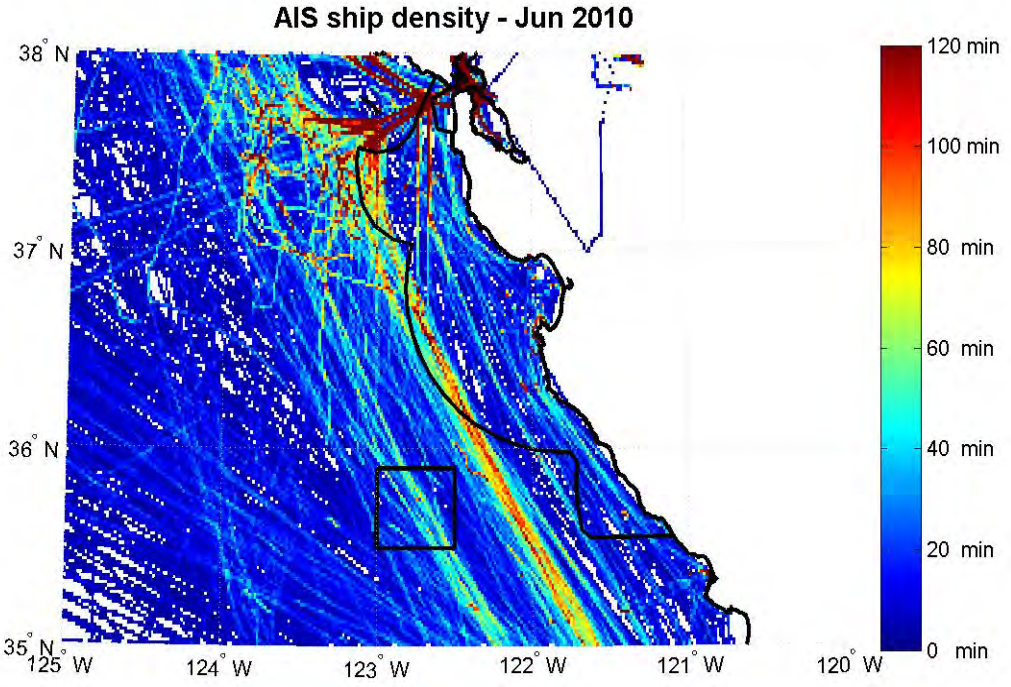

Figure 19. Monthly ship density for June 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

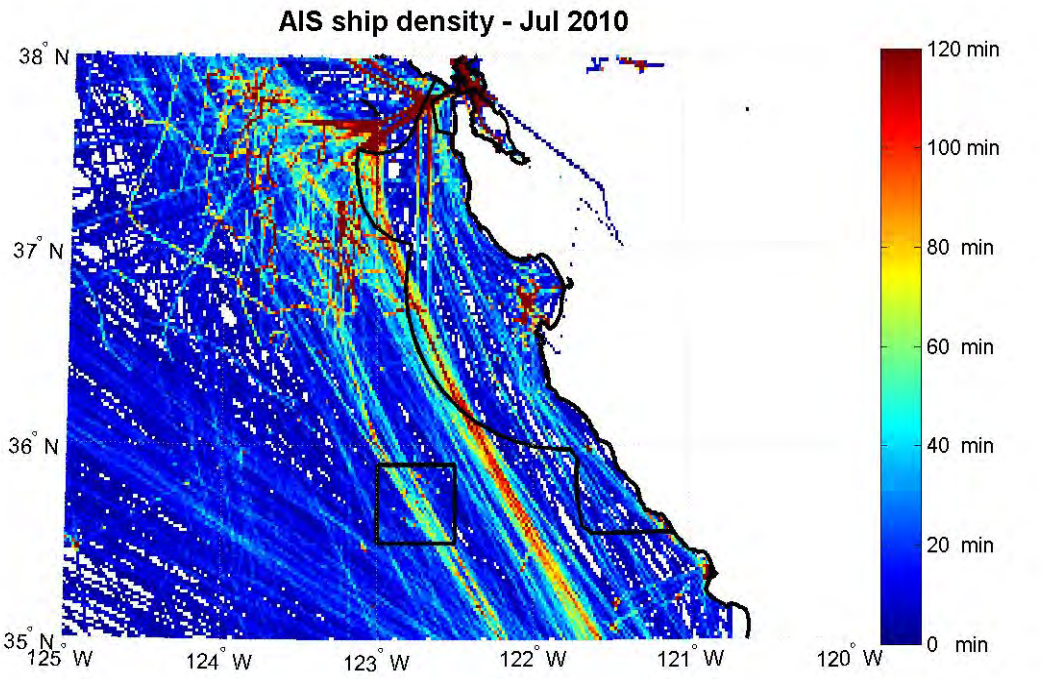

Figure 20. Monthly ship density for July 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

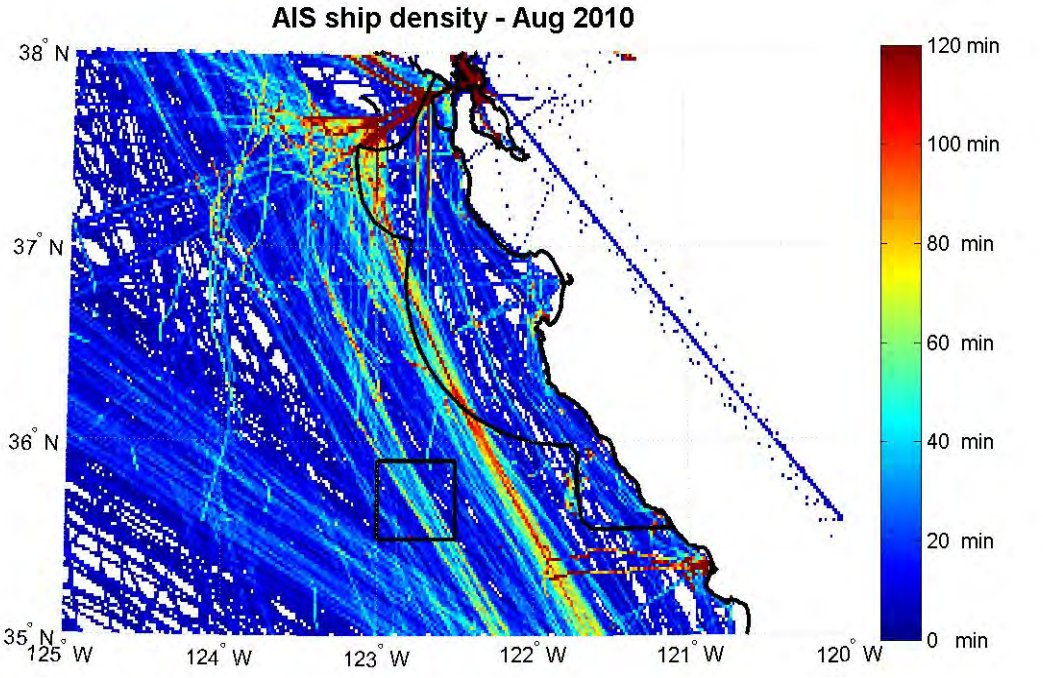

Figure 21. Monthly ship density for August 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

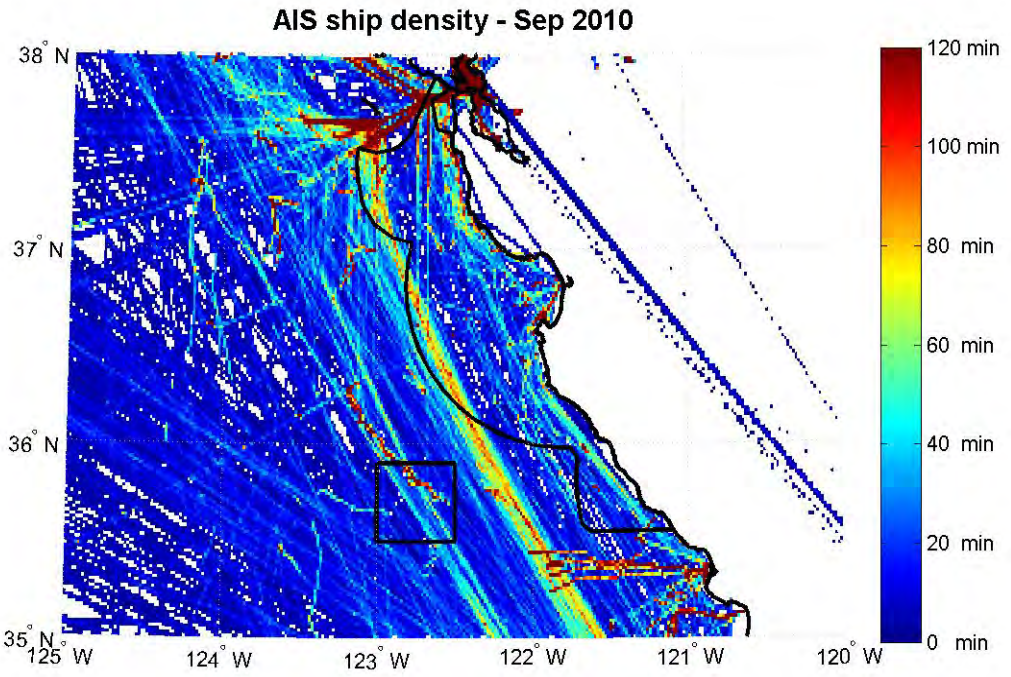

Figure 22. Monthly ship density for September 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

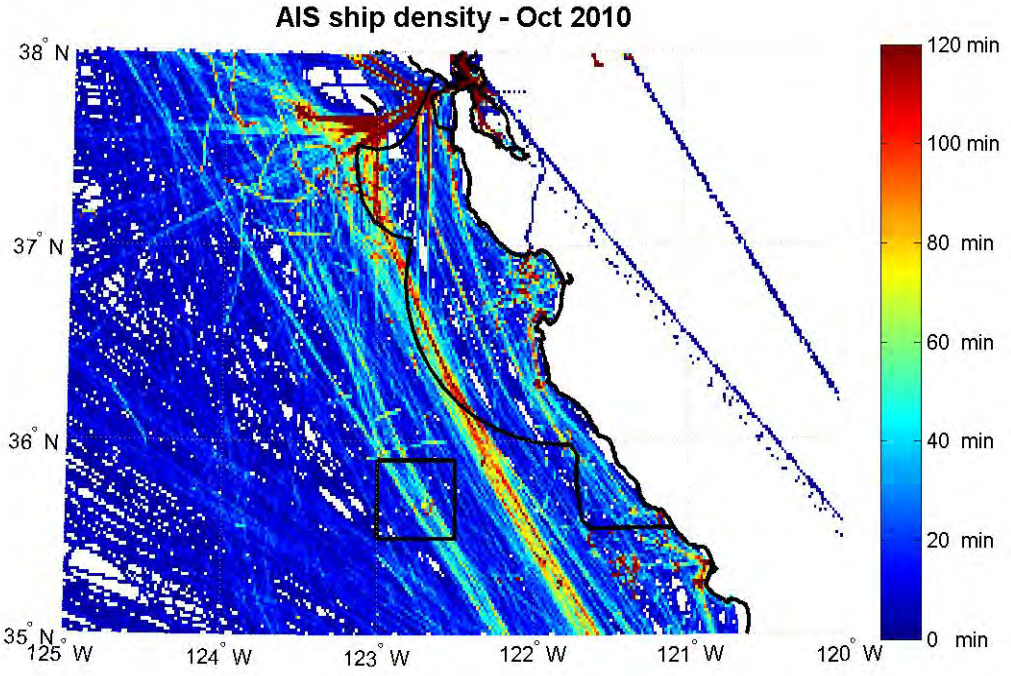

Figure 23. Monthly ship density for October 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

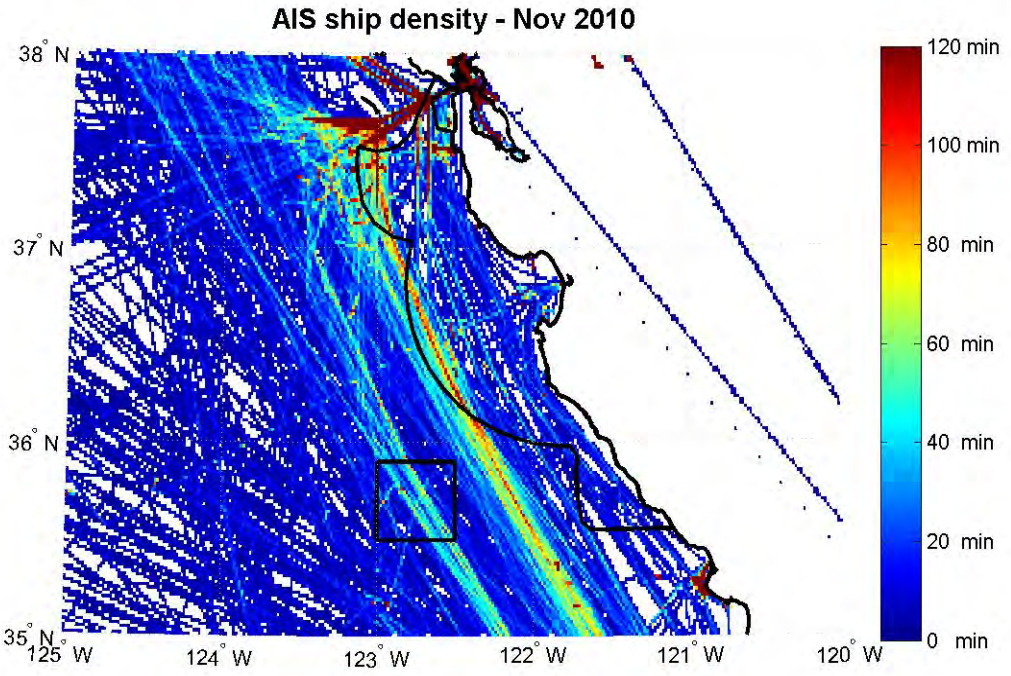

Figure 24. Monthly ship density for November 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

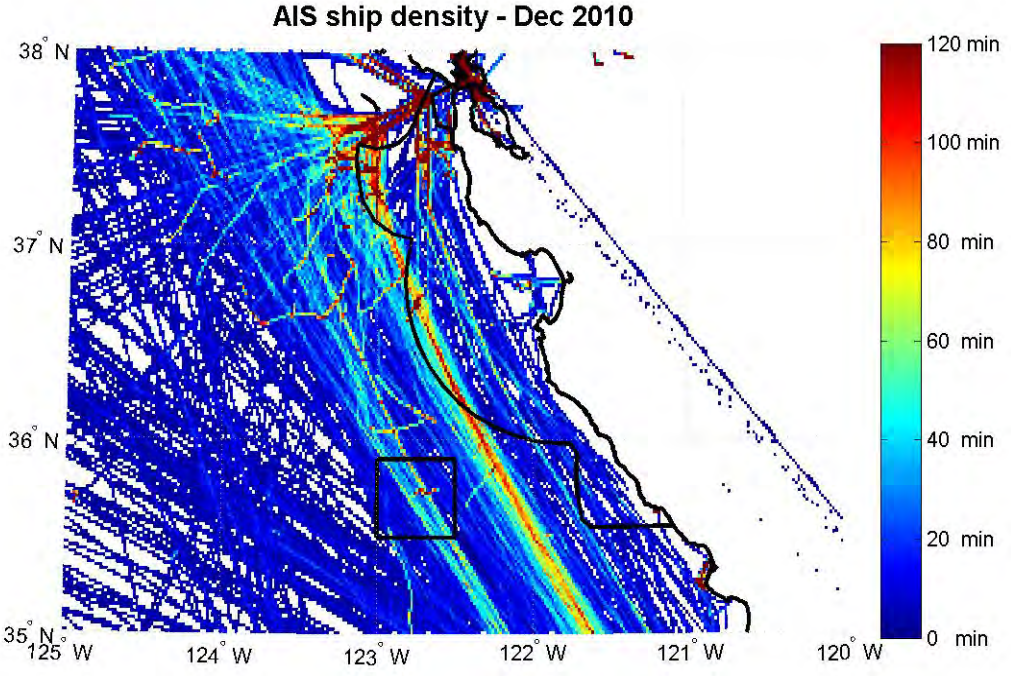

Figure 25. Monthly ship densities for December 2010. Positions appearing over land are interpolation errors caused by large gaps in the available position reports and/or improperly configured AIS hardware reporting bad data.

C. MONTHLY CARGO DENSITIES

The AIS messages were further categorized by reported ship type, with all cargo class vessels isolated and monthly location totals calculated. The monthly cargo ship density plots are shown in figures 26-37. Similar to the total shipping densities, the color axis was clipped at 120 minutes in order to preserve enough contrast in the seagoing data to show the higher traffic areas.

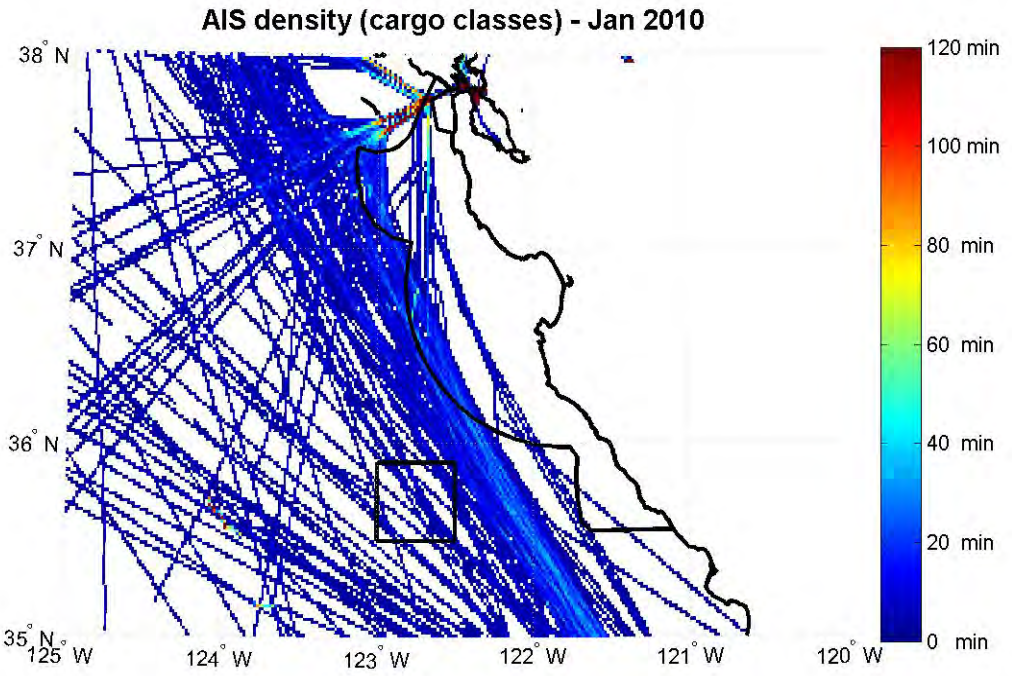

Figure 26. AIS cargo vessel density for January 2010.

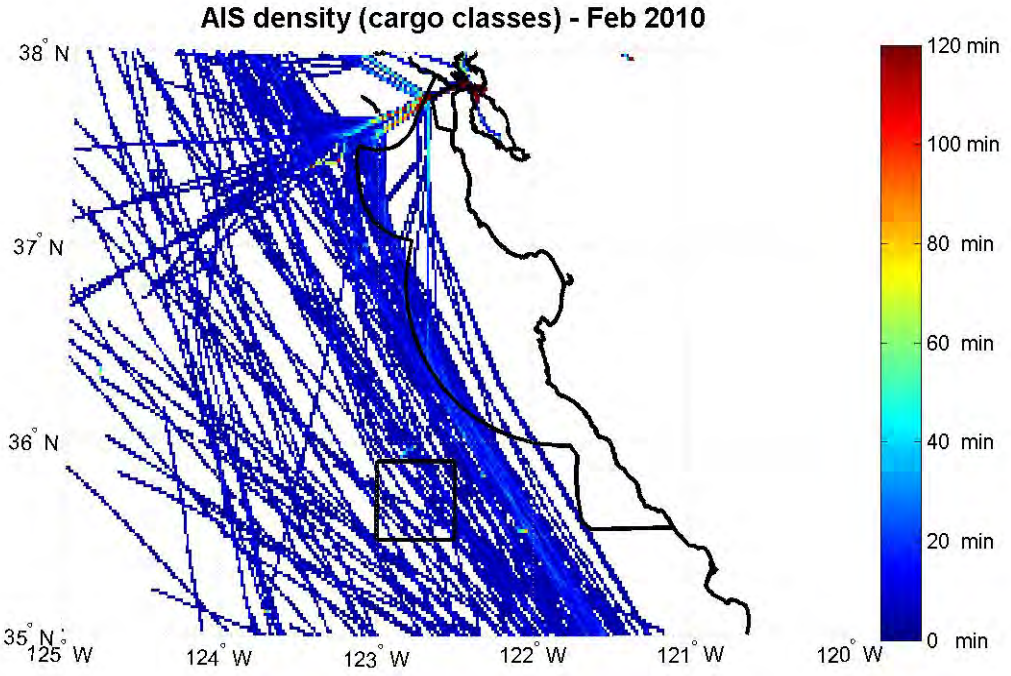

Figure 27. AIS cargo vessel density for February 2010.

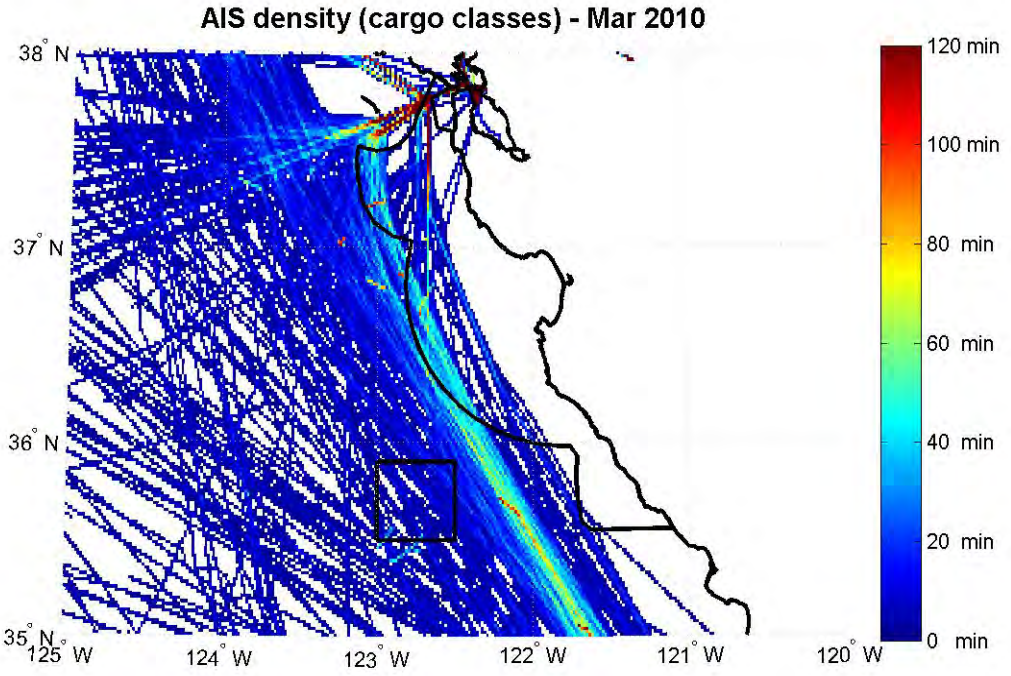

Figure 28. AIS cargo vessel density for March 2010.

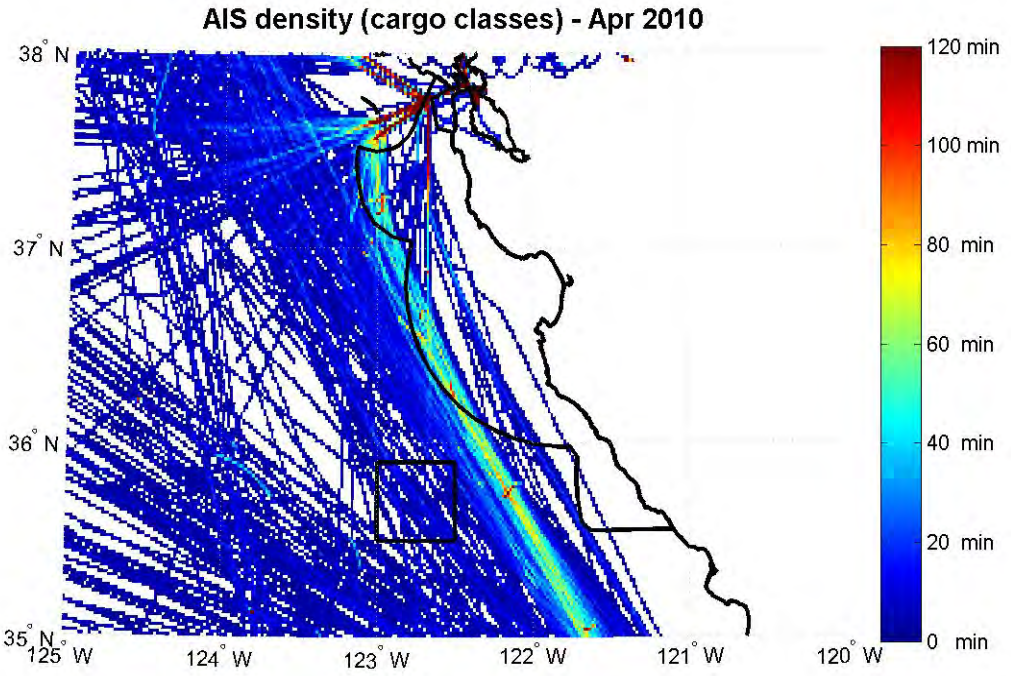

Figure 29. AIS cargo vessel density for April 2010.

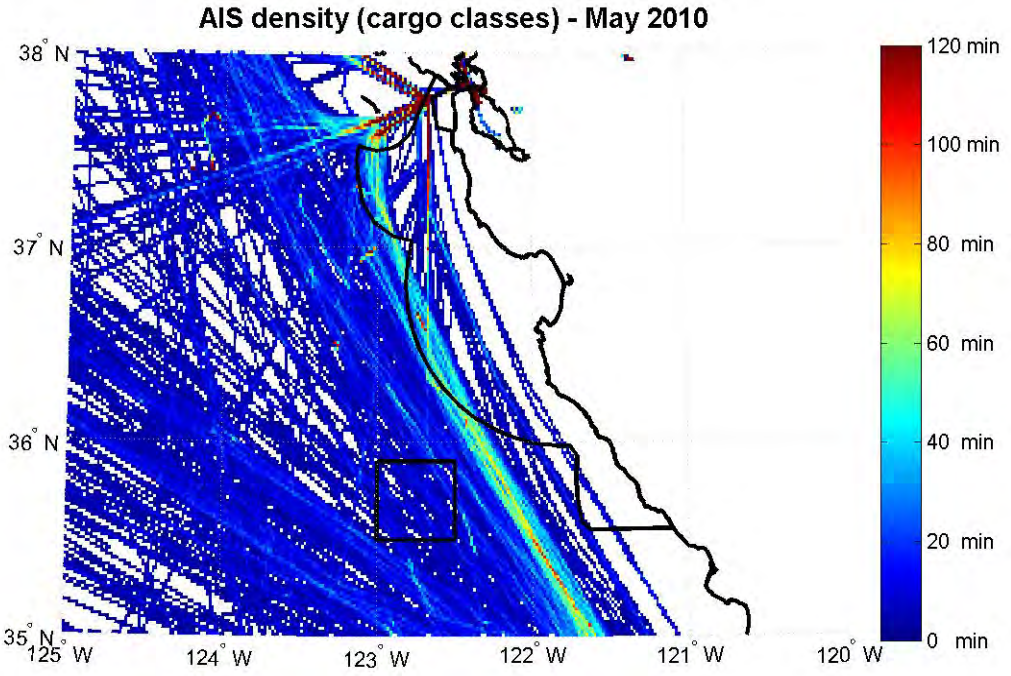

Figure 30. AIS cargo vessel density for May 2010.

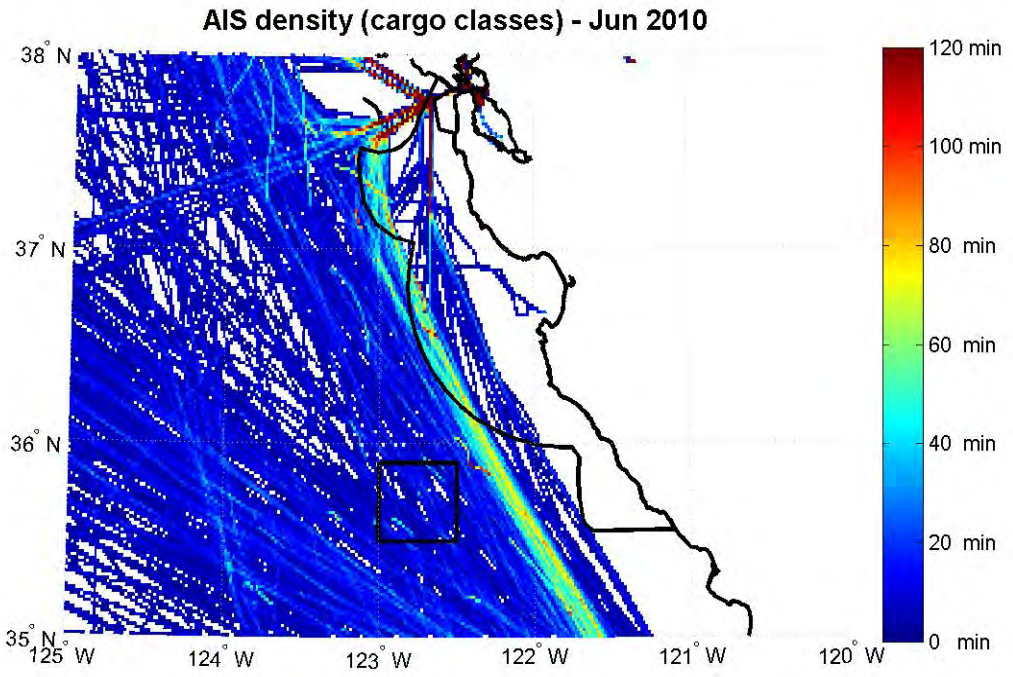

Figure 31. AIS cargo vessel density for June 2010.

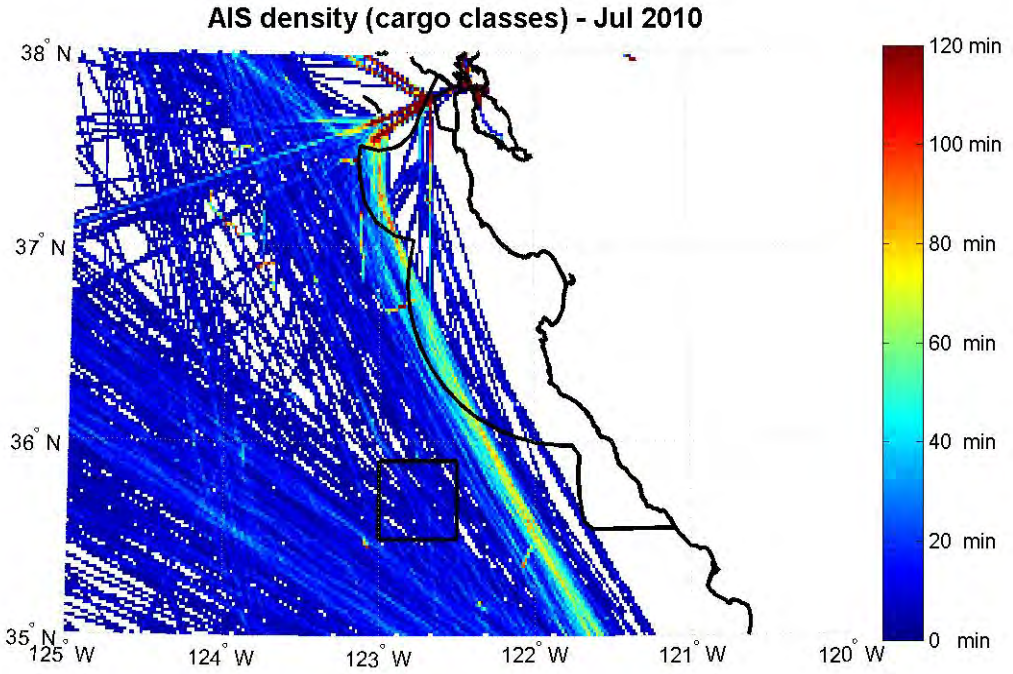

Figure 32. AIS cargo vessel density for July 2010.

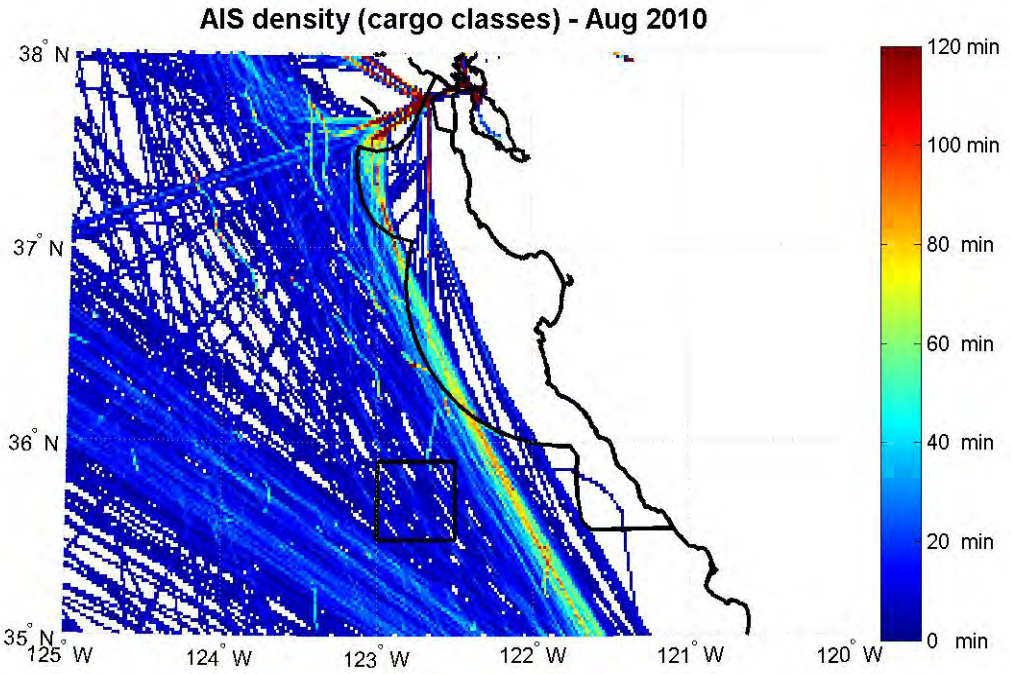

Figure 33. AIS cargo vessel density for August 2010.

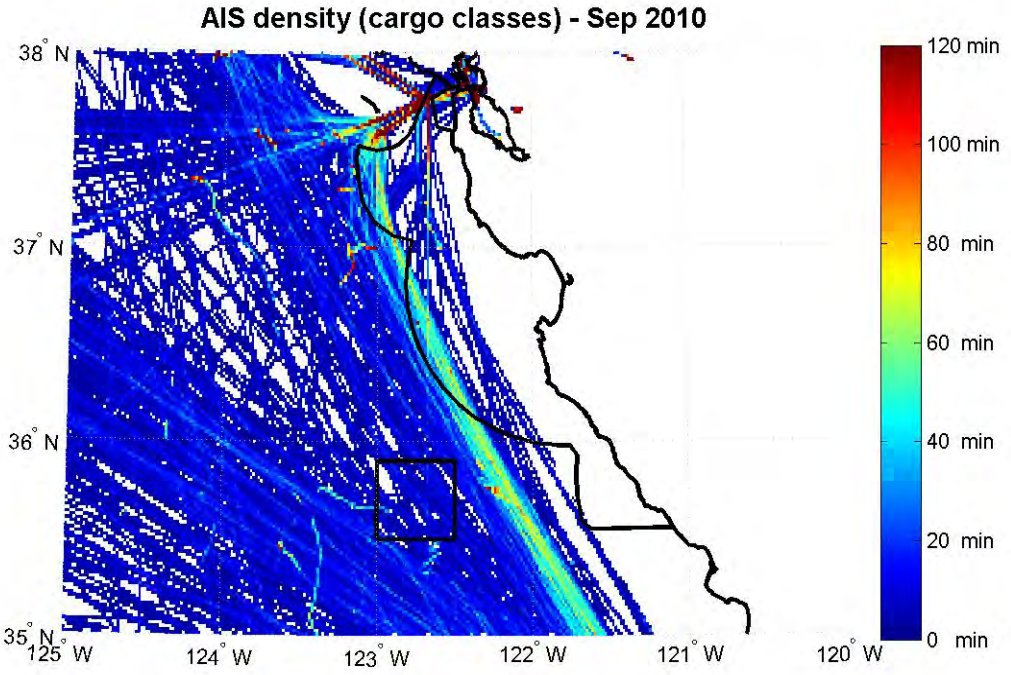

Figure 34. AIS cargo vessel density for September 2010.

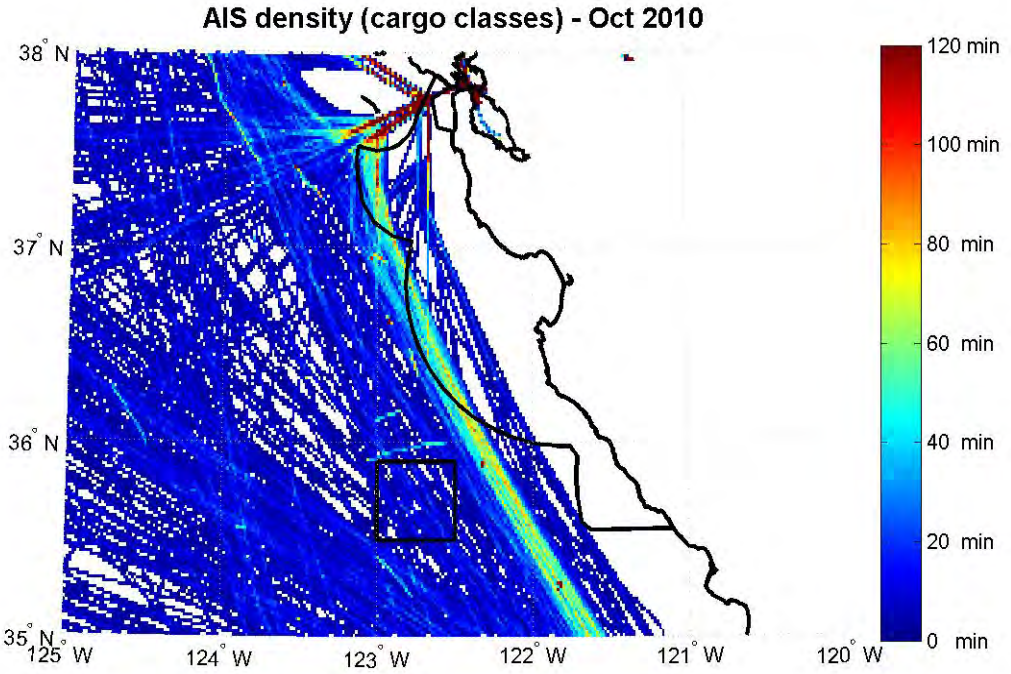

Figure 35. AIS cargo vessel density for October 2010.

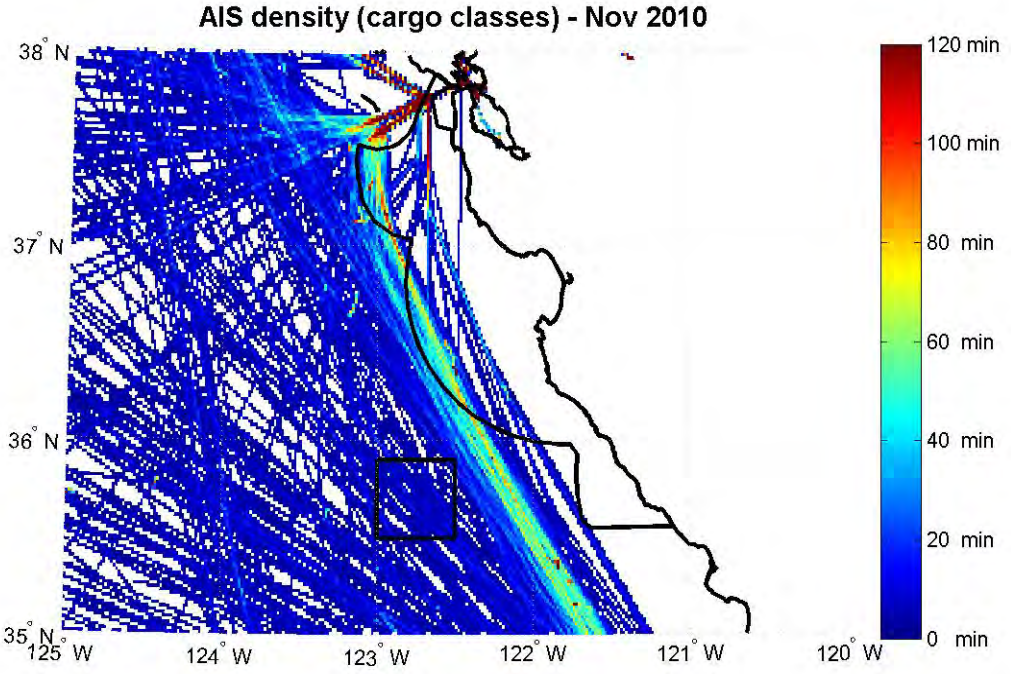

Figure 36. AIS cargo vessel density for November 2010.

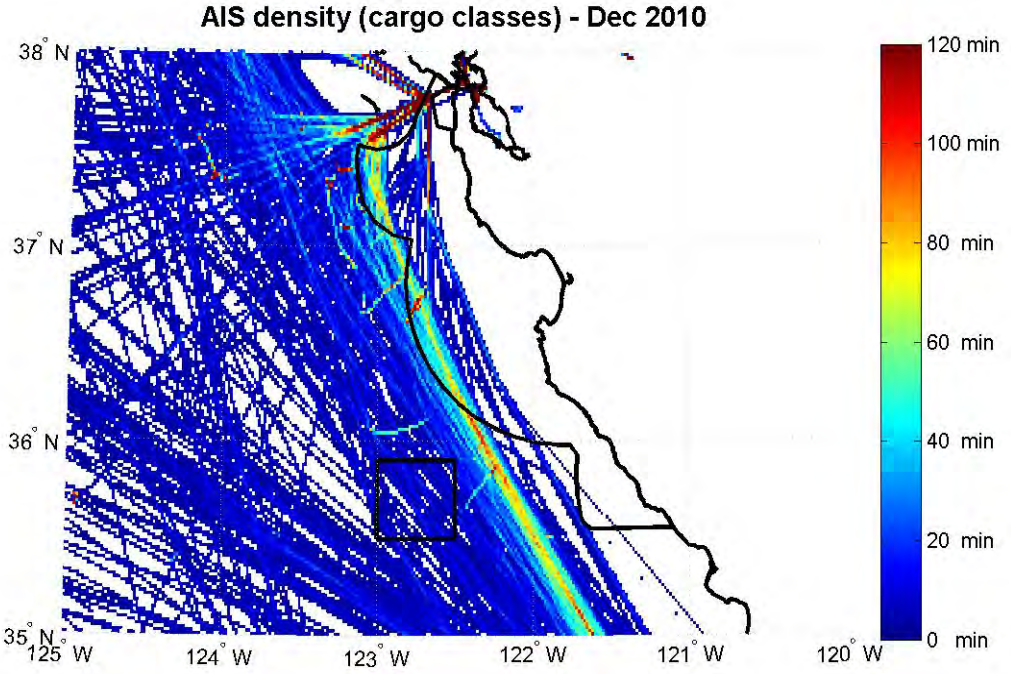

Figure 37. AIS cargo vessel density for December 2010.

II. SUMMARY

The cargo class vessels comprise 40-50% of all vessel traffic within the Monterey Bay National Marine Sanctuary, however they are generally contained within the prescribed shipping lanes, and most incursions occur at the San Francisco Bay approach.

It should be noted that the cargo ship totals shown in Table 2 were tallied from individual daily reports, so those vessels that were transiting at 00:00 GMT are counted twice, once in each day's data set in which they appeared. As this is also true of the total vessel count. These values are provided only to provide a general sense of shipping distribution within the Sanctuary, as absolute figures are not possible due to the variability and gaps in the AIS data coverage, vessels transmitting incorrect default MMSI identifier (so all information from that vessel is suspect).

Table 2. 2010 cargo vessel daily totals, grouped monthly, which passed through the coastal Monterey Bay National Marine Sanctuary (excluding the Davidson Seamount management zone).

Month	Cargo Class	Total Vessels	% cargo
January	178	362	49
February	126	242	52
March	345	737	47
April	366	805	45
May	396	937	42
June	435	1000	44
July	439	1023	43
August	443	943	47
September	394	976	40
October	453	1053	43
November	426	858	50
December	471	877	54

Table 3. 2010 cargo vessel daily totals, grouped monthly, which passed through the Davidson Seamount Management Zone.

Month	Cargo Class	Total Vessels	% Cargo
January	30	70	43
February	30	57	53
March	66	159	42
April	55	152	36
May	89	203	44
June	93	204	46
July	82	191	43
August	83	192	43
September	81	170	48
October	73	185	39
November	57	158	36
December	72	165	44

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